LISTS OF SPECIES

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# Mammals of four Caatinga areas in northeastern Brazil: inventory, species biology, and community structure

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**Abstract:** Studies on population dynamics and community structure for mammals from the semi-arid Caatinga biome are very scarce. I surveyed non-volant mammals in four sites in the Caatinga of Northeastern Brazil. Herein, 24 species belonging to eight orders are recorded. A total of 165 individuals of five species of small mammals were captured in a 4-year capture-recapture study. Capture success and relative richness were low and not correlated with precipitation and temperature. The present study contributes to the knowledge of species biology and ecology in sites geographically close to priority areas for conservation in this biome.

**Key words:** camera trap; capture-recapture method; inventory; Mammalia; semi-arid

## INTRODUCTION

The Caatinga is a Brazilian biome that covers most of semi-arid Northeastern Brazil (Leal et al. 2005; Albuquerque et al. 2012). Its vegetation is characterized by a mosaic of thorn scrubs and seasonally dry forests (Leal et al. 2005). The Caatinga has two seasons (dry and wet), which are characterized by a prolonged drought and the unpredictability of the rainy season (Streilein 1982; Leal et al. 2005). It occupies an area of approximately 750,000 km$^2$ (Leal et al. 2005). However, from 30% to 52% of the Caatinga biome has been degraded by agriculture, goat and cattle rearing, and other anthropogenic activities, ranking it as the third most degraded Brazilian biome (Leal et al. 2005).

Studies on mammals from the Caatinga have increased considerably in recent years, but there are still many geographical areas within this biome that have not yet been studied (Albuquerque et al. 2012). Most of these recent studies focus on species taxonomy and geographic distribution (e.g., Geise et al. 2010; Olifiers and Delciellos 2013; Bezerra et al. 2015), while capture-recapture studies to understand population dynamics in this semi-arid environment remain practically non-existent (e.g., Streilein 1982). In the most recent list, Carmignotto et al. (2012) reported 76 species of non-volant mammals from this biome, with about 14% of these representing endemics (Oliveira et al. 2003a).

In this study, I surveyed different groups of mammals in four sites in the Caatinga of São João do Piauí (state of Piauí), and Ouricuri (state of Pernambuco), Northeastern Brazil. These study sites are geographically close to priority areas for conservation of mammals in the Caatinga (MMA 2002). Data on abundance based on a capture-recapture study and community structure for non-volant small mammals, and notes on species biology and conservation are discussed.

## MATERIALS AND METHODS

### Study sites

The study sites are located in the municipalities of São João do Piauí, state of Piauí, and Ouricuri, state of Pernambuco, Brazil (Figure 1). The climate of São João do Piauí is BSh following the Köppen classification, with mean annual temperature between 26°C and 28°C and annual precipitation between 660 and 800 mm (Azevêdo et al. 2008). August is the driest month, and March is the month with the highest rainfall (Climate-data.org 2016). Vegetation is classified as Savana Estépica Arborizada and Savama Estépica Parque, both within in the Caatinga biome (IBGE 2004). Non-volant small mammals samplings were carried out at two sites: site 1 (08°18′34.4″ S, 042°18′15.8″ W), and site 2 (08°16′0.9″ S, 042°05′28.4″ W), located ca. 13 km and 32 km from Serra da Capivara National Park, respectively (Figure 1). Medium-sized and large mammal samplings were carried out in the surroundings of these two sites, and along the nearest highways PI-142, PI-459 and BR-020.

The climate of Ouricuri is BSwh' following Köppen classification, with mean annual temperature of 26°C and annual precipitation of 650 mm (Oliveira et al.

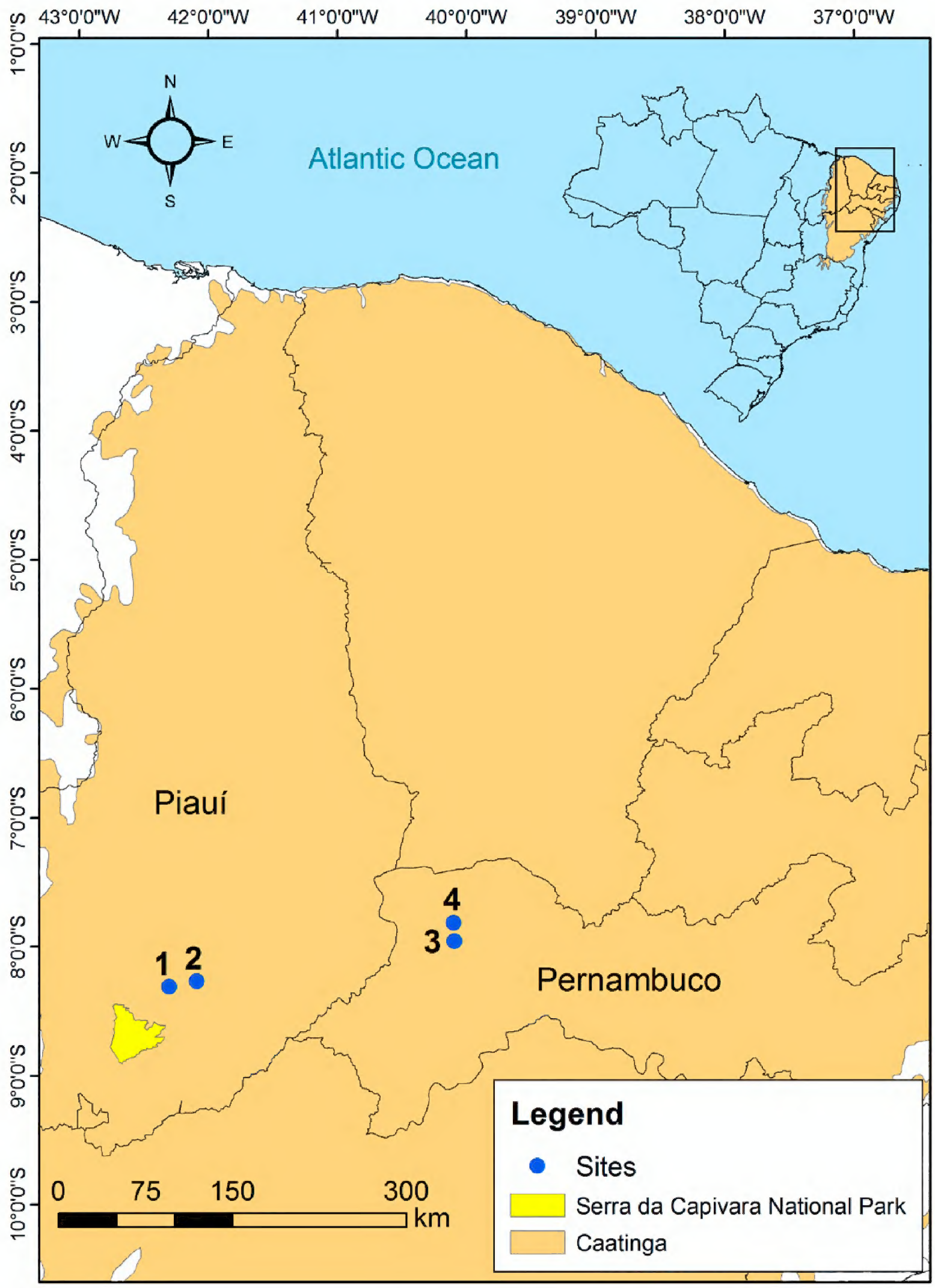


**Figure 1.** Study sites (circles) in the municipalities of São João do Piauí (sites 1 and 2), state of Piauí, and Ouricuri (sites 3 and 4), state of Pernambuco, northeastern Brazil.

2003b). August is the driest month, and March is the month with the highest rainfall (Climate-data.org 2016). Vegetation is classified as Savana Estépica Parque (IBGE 2004). Non-volant small mammals samplings were carried out in two sites: site 3 (07°57′26.3″ S, 040°05′27.2″ W), and site 4 (07°48′49.2″ S, 040°05′56.0″ W) (Figure 1). Medium-sized and large mammals samplings were carried out in the surroundings of these sites, and along the nearest highways BR-122 and BR-316.

## Non-volant small mammals sampling

Small mammals belonging to the orders Rodentia and Didelphimorphia were sampled using live traps and pitfall traps. Two sampling sessions were conducted in 2010 (April and October), 2011 (March and September), 2012 (April and December), and 2013 (April and October), totalizing eight sampling sessions in each site. One additional sampling was realized in June 2010, but the data yielded were used only for species inventory. Each sampling session had five consecutive nights in

each site, except by the first trap session in 2010 that had three to four consecutive nights.

Two 435 m transects were established at each sampling site, each with 30 trap stations 15 m apart from each other. Each station had one Tomahawk® placed on the floor, and in the odd points also had a Sherman® trap placed between 1.0 and 1.5 m above ground. Live traps were checked in the morning, beginning at dawn to avoid animals be killed by heat, and the bait replaced if necessary. The bait was composed of a mixture of bananas, sardines, ground peanuts, and corn flour. The total sampling effort was 3,730 trap-nights in site 1; 3,708 in site 2; and 3,960 in sites 3 and 4 (excluding additional sample session from June 2010).

Two lines of five 60-litre plastic buckets, 15 m apart from each other, were established in each sampling site. The buckets were connected by a plastic-sheet drift fence 0.5 m high perpendicularly to the ground in order to induce the capture of wandering individuals. All pitfall traps were checked in the morning. The total sampling effort in each site was 400 bucket-nights.

Individuals trapped were identified at the species level whenever possible. For each individual captured, I recorded its body mass (using spring scales [Pesola™; see Appendix, Table A1]), sex, their reproductive condition; trap station; head-body and tail length (Appendix, Table A1); and age (only for didelphids, Macedo et al. 2006). After the handling procedure, animals were marked with a numbered ear-tag on first capture (Ear Tags, National Band & Tag Co., Newport, Kentucky, USA), and released at the place of capture. Unidentified specimens were collected and deposited at the Museu Nacional, Universidade Federal do Rio de Janeiro (Appendix, Table A2; IBAMA/MMA, process no. 02001.001113/2008-11, authorization no. 192/2010).

**Survey of medium-sized and large mammals**

Medium and large-sized mammal species were sampled in the four sites by camera traps, active search for direct and indirect evidence, and censuses at night. Eight sampling sessions were conducted, which were concomitant with the trap sessions for small mammals.

In each sampling session, two to five camera traps were placed up to 0.5 m above the ground in each sampling site, slightly oriented downwards, from three to five consecutive nights, and kept active daylong (24 h). Cameras were automatically triggered by both heat and motion. The bait consisted of pineapple, banana, salt, bacon, sardines and bobcat urine placed in the camera's focus. The total sampling effort was 170 days/nights in site 1; 178 days/nights in site 2; 195 days/nights in site 3; and 178 days/nights in site 4 (considering additional sample session of June 2010).

Active search was performed in sites where there was greater likelihood to record mammals by indirect traces, e.g., near weirs. Censuses at night were conducted by vehicle along paved and unpaved roads within and around sampling sites and utilized an observer with a spotlight in the back of a pickup truck traveling at 20 km/h. For direct (observed animals) or indirect evidence (e.g., burrows, vocalizations, and tracks), I recorded: genus or species using field guides (Auricchio 1995; Becker and Dalponte 1999; Lima-Borges and Thomás 2004; Oliveira and Cassaro 2005); location and altitude using a GPS receiver; and hour and number of individuals, when possible. The identification of armadillo burrows followed Lima-Borges and Thomás (2004). The total sampling effort of active search and censuses at night was 43 h in site 1; 46 h in site 2; 47 h in site 3; and 45 h in site 4 (considering additional sampling session of June 2010). Road-killed animals were collected whenever possible and deposited at the Museu Nacional, Universidade Federal do Rio de Janeiro (Appendix, Table A2; IBAMA/MMA, process no. 02001.001113/2008-11, authorization no. 192/2010).

**Taxonomic classification**

I followed the taxonomic classification proposals of Bonvicino et al. (2008), Carmignotto et al. (2012), and Patton et al. (2015). For those researchers who follow the recent propositions of Feijó and Langguth (2013) and Gurgel-Filho et al. (2015), change *Necromys lasiurus* to *Bolomys lasiurus*, *Calomys expulsus* to *C. mattevii*, *Conepatus semistriatus* to *C. amazonicus*, and *Didelphis albiventris* to *D. marsupialis*.

**Data analysis**

For each site, capture success was measured as the total number of captures divided by sampling effort, and relative richness as total richness divided by sampling effort. Spearman correlations were performed in Statistica 8.0 software (Stat Soft Inc. 1984–2007) to evaluate the relation between monthly precipitation and mean compensated temperature and these parameters. Monthly precipitation and mean compensated temperature for São João do Piauí and Ouricuri municipalities were obtained from Instituto Nacional de Meteorologia (INMET 2016). Each analysis was also repeated considering a time-lag of three months for species to respond to variations on these variables (Metzger et al. 2009). Values of abundance for each species were considered the number of different individuals captured in each trap session. For non-volant small mammals in each site, species richness was estimated using Chao1, an abundance-based non-parametric estimator (Colwell and Coddington 1994). This estimator adds to the observed richness a number of non-observed species based on the number of rare species in the sample (Colwell and Coddington 1994). These analyses were performed on EstimateS 9.1 software (Colwell 2013).

## RESULTS

Twenty-four species of mammals belonging to eight orders were recorded in all sites: Rodentia (37.5%), Carnivora (25.0%), Didelphimorphia (12.5%), Cingulata (8.3%), Lagomorpha (4.2%), Pilosa (4.2%), Primates (4.2%), and Artiodactyla (4.1%) (Table 1).

A total of 165 individuals belonging to five species of non-volant small mammals (*Didelphis albiventris*, *Galea spixii*, *Gracilinanus agilis*, *Thrichomys laurentius*, and *Wiedomys pyrrhorhinos*) were captured with live traps (Table 1; Figure 2). *Thrichomys laurentius* had the highest relative abundance in all sites but site 2 (Figure 3). Species richness and capture success were higher in Ouricuri than in São João do Piauí sites (Figure 4; Table 2) and were not correlated with temperature and precipitation in all sites (Table 3). Species-accumulation curves (observed

**Table 1.** Mammals species recorded in the municipalities of São João do Piauí, state of Piauí (sites 1 and 2), and Ouricuri, state of Pernambuco (sites 3 and 4), northeastern Brazil. Type of record: B= burrow; C= carcass, CA= capture; CT= camera trap; FC= feces; FT= footprints; PIT= pitfall trap; RO= road-killed; V= vocalization; VI= visual observation.

| | | Record | | | |
|---|---|---|---|---|---|
| **Taxon** | **Common Name** | **1** | **2** | **3** | **4** |
| **ORDER CARNIVORA** | | | | | |
| **Family Canidae** | | | | | |
| *Cerdocyon thous* (Linnaeus, 1766) | Crab-eating Fox | CT, FT, RO, VI | CT, FT, RO, VI | CT, FT, VI | CT, RO, VI |
| **Family Felidae** | | | | | |
| *Leopardus pardalis* (Linnaeus, 1758) | Ocelot | | | | FT |
| *Leopardus tigrinus* (Schreber, 1775) | Oncilla | VI | VI | | VI |
| *Leopardus* sp. | | CT | VI | CT | CT |
| *Puma yagouaroundi* (É. Geoffory Saint-Hilaire, 1803) | Jaguarundi | VI | C | | |
| **Family Mephitidae** | | | | | |
| *Conepatus semistriatus* (Boddaert, 1784) | Hog-nosed Skunk | VI | VI | CA, CT, FT | CA, VI |
| **Family Procyonidae** | | | | | |
| *Procyon cancrivorus* (Cuvier, 1798) | Crab-eating Raccoon | FT, RO | CT, FT, VI | FT, VI | CT, FT |
| **ORDER CINGULATA** | | | | | |
| **Family Dasypodidae** | | | | | |
| *Dasypus septemcinctus* (Linnaeus, 1758) | Seven-banded Armadillo | PIT | | | |
| *Euphractus sexcinctus* (Wagler, 1830) | Six-banded Armadillo | B, FT, VI, C | B, CA | | B |
| **ORDER DIDELPHIMORPHIA** | | | | | |
| **Family Didelphidae** | | | | | |
| *Didelphis albiventris* Lund, 1840 | White-eared Opossum | CA, VI | CA, VI | CA, CT, VI | CA, CT, VI |
| *Gracilinanus agilis* (Burmeister, 1854) | Agile Gracile Opossum | CA | CA | CA, PIT | CA |
| *Monodelphis domestica* (Wagner, 1842) | Grey Short-tailed Opossum | CA, PIT | CA | | |
| **ORDER LAGOMORPHA** | | | | | |
| **Family Leporidae** | | | | | |
| *Sylvilagus brasiliensis* (Linnaeus, 1758) | Tapeti | VI | FT, VI | | |
| **ORDER PILOSA** | | | | | |
| **Family Myrmecophagidae** | | | | | |
| *Tamandua tetradactyla* (Linnaeus, 1758) | Southern Tamandua | | VI | | |
| **ORDER ARTIODACTYLA** | | | | | |
| **Family Cervidae** | | | | | |
| *Mazama* sp. | Brocket | CT, FT | | CT, VI | CT, FT |
| **ORDER PRIMATES** | | | | | |
| **Family Callitrichidae** | | | | | |
| *Callithrix jacchus* (Linnaeus, 1758) | Common Marmoset | V, VI | VI | V, VI | V, VI |
| **ORDER RODENTIA** | | | | | |
| **Family Caviidae** | | | | | |
| *Cavia* sp. | Guinea Pig | VI | | | |
| *Galea spixii* (Wagler, 1831) | Spix's Yellow-toothed Cavy | CA | CA, VI | CA, CT, VI | CA |
| *Kerodon rupestris* (Wied, 1820) | Rock Cavy | | FC | FC, VI | |
| **Family Cricetidae** | | | | | |
| *Calomys expulsus* (Lund, 1841) | Caatinga Laucha | | | | PIT |
| *Necromys lasiurus* (Lund, 1841) | Hairy-tailed Bolo Mouse | | | PIT | PIT |
| *Oligoryzomys stramineus* Bonvicino & Weksler, 1998 | Straw-colored Colilargo | | | PIT | PIT |
| *Wiedomys pyrrhorhinos* (Wied-Neuwied, 1821) | Red-nosed Mouse | CA | CA, VI | CA, VI | CA |
| **Family Dasyproctidae** | | | | | |
| *Dasyprocta prymnolopha* Wagler, 1841 | Black-rumped Agouti | | C, CT, VI | | |
| **Family Echimyidae** | | | | | |
| *Thrichomys laurentius* Thomas, 1904 | Punaré | CA, VI | | CA, VI | CA, CT |

**Figure 2.** Non-volant small mammals species recorded in Caatinga areas in the municipalities of São João do Piauí, state of Piauí, and Ouricuri, state of Pernambuco, northeastern Brazil: **A)** *Didelphis albiventris*; **B)** *Gracilinanus agilis*; **C)** *Monodelphis domestica*; **D)** *Calomys expulsus*; **E)** *Galea spixii*; **F)** *Oligoryzomys stramineus*; **G)** *Thrichomys laurentius*; **H)** *T. laurentius*; **I)** *Wiedomys pyrrhorhinos*. Photos by Ana C. Delciellos.

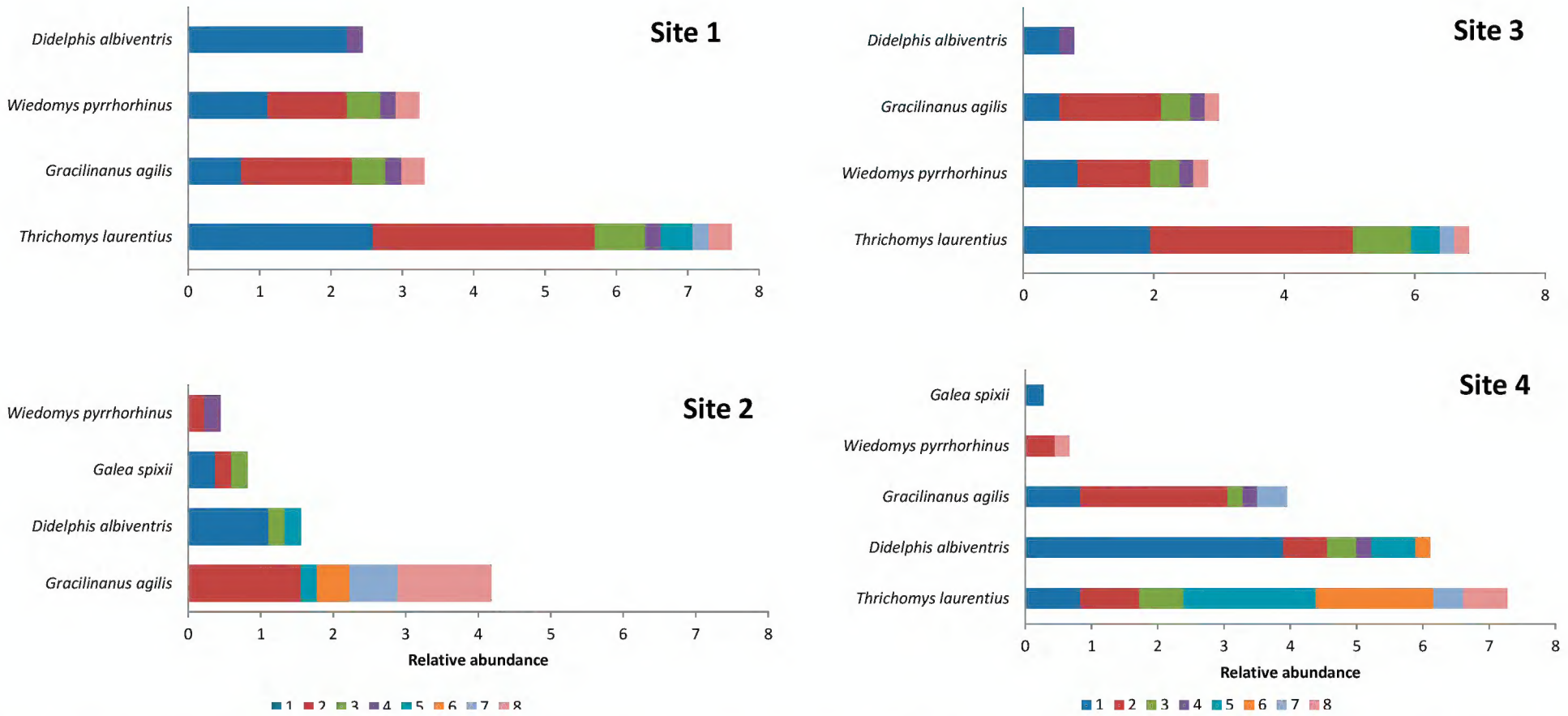


**Figure 3.** Relative abundance of non-volant small mammals species captured with live-traps in each trap session in São João do Piauí, state of Piauí (sites 1 and 2), and Oricuri, state of Pernambuco (sites 3 and 4), northeastern Brazil. August is the driest month, and March is the month with the highest rainfall. 1= April 2010; 2= October 2010; 3= March 2011; 4= October 2011; 5= April 2012; 6= December 2012; 7= April 2013; 8= October 2013.

**Table 2.** Species richness (S), abundance (AB) and capture success (CS) of non-volant small mammals captured with live-traps in the municipalities of São João do Piauí, state of Piauí (sites 1 and 2), and Ouricuri, state of Pernambuco (sites 3 and 4), northeastern Brazil. In all sites, August is the driest month, and March is the month with the highest rainfall.

| | | Sampling session | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| | | April 2010 | October 2010 | March 2011 | October 2011 | April 2012 | December 2012 | April 2013 | October 2013 | Mean |
| Site 1 | S | 2 | 4 | 1 | 3 | 3 | 0 | 1 | 0 | 1.8 |
| | AB | 2 | 7 | 1 | 4 | 6 | 0 | 4 | 0 | 3.0 |
| | CS (%) | 1.1 | 1.8 | 0.2 | 1.3 | 1.8 | 0.0 | 0.9 | 0.0 | 0.9 |
| Site 2 | S | 2 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1.8 |
| | AB | 4 | 9 | 2 | 3 | 2 | 2 | 1 | 4 | 3.4 |
| | CS (%) | 1.5 | 2.2 | 0.4 | 0.7 | 0.4 | 0.4 | 0.2 | 1.3 | 0.9 |
| Site 3 | S | 3 | 3 | 3 | 4 | 1 | 0 | 0 | 0 | 1.8 |
| | AB | 16 | 26 | 7 | 4 | 2 | 0 | 0 | 0 | 6.9 |
| | CS (%) | 4.7 | 6.4 | 1.8 | 0.9 | 0.4 | 0.0 | 0.0 | 0.0 | 1.8 |
| Site 4 | S | 4 | 4 | 3 | 2 | 2 | 2 | 1 | 1 | 2.4 |
| | AB | 20 | 20 | 6 | 2 | 12 | 9 | 2 | 2 | 9.1 |
| | CS (%) | 7.2 | 5.1 | 1.3 | 0.4 | 3.6 | 2.4 | 0.4 | 0.7 | 2.6 |

richness) reach their asymptotes in all sites, but estimated richness (Chao1) for sites 3 and 4 (Ouricuri) were higher than the observed richness (Figure 4). Peaks of abundance were observed in October 2010 (dry season) in all sites and species, except for *D. albiventris* (Figure 5). Other four species (*Calomys expulsus*, *Monodelphis domestica*, *Necromys lasiurus*, and *Oligoryzomys stramineus*) were eventually (< 4 captures) captured during the study (Table 1).

## Notes on species biology, abundance and conservation

Order Carnivora

*Cerdocyon thous* had the highest number of records among medium-sized and large mammals in all sites and sampling sessions (Table 1; Figures 6 and 7). During active searches for direct and indirect traces and censuses at night, 63 independent records were obtained. During censuses at night, 37% of the visual observations were of two individuals. Solitary individuals to groups of four individuals were recorded in camera traps. On June 2010 (dry season), two adults and two young individuals were recorded in the same photo in site 1 (Figure 7). Also, five road-killed individuals were found, including one individual in the highway PE-585 (State of Pernambuco; 05°29′40.6″ S, 040°27′04.2″ W; datum WGS84) out the study area. One domesticated individual was record in site 2 (Figure 6). *Conepatus semistriatus* was recorded by two individuals captured in Tomahawks (sites 3 and 4; Figure 6), records in cameras traps (Figure 7), one road-killed individual in the highway PI-143 (Municipality

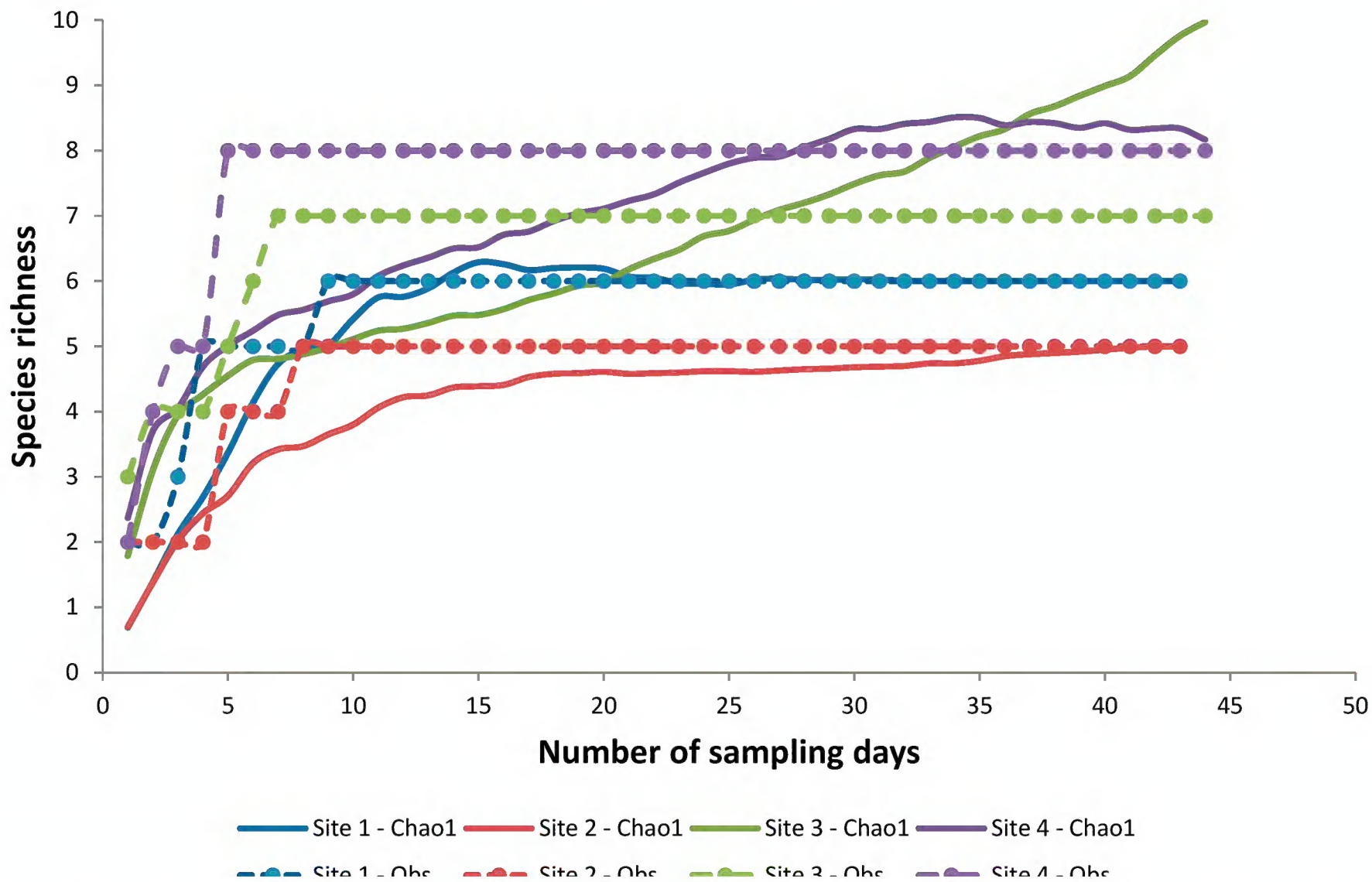


**Figure 4.** Observed (Obs) and estimated (Chao1) species richness of non-volant small mammals species captured in São João do Piauí, state of Piauí (sites 1 and 2), and Oricuri, state of Pernambuco (sites 3 and 4), northeastern Brazil. Observed richness is the accumulated number of species record in each site. Estimated species was done using Chao1 estimator.

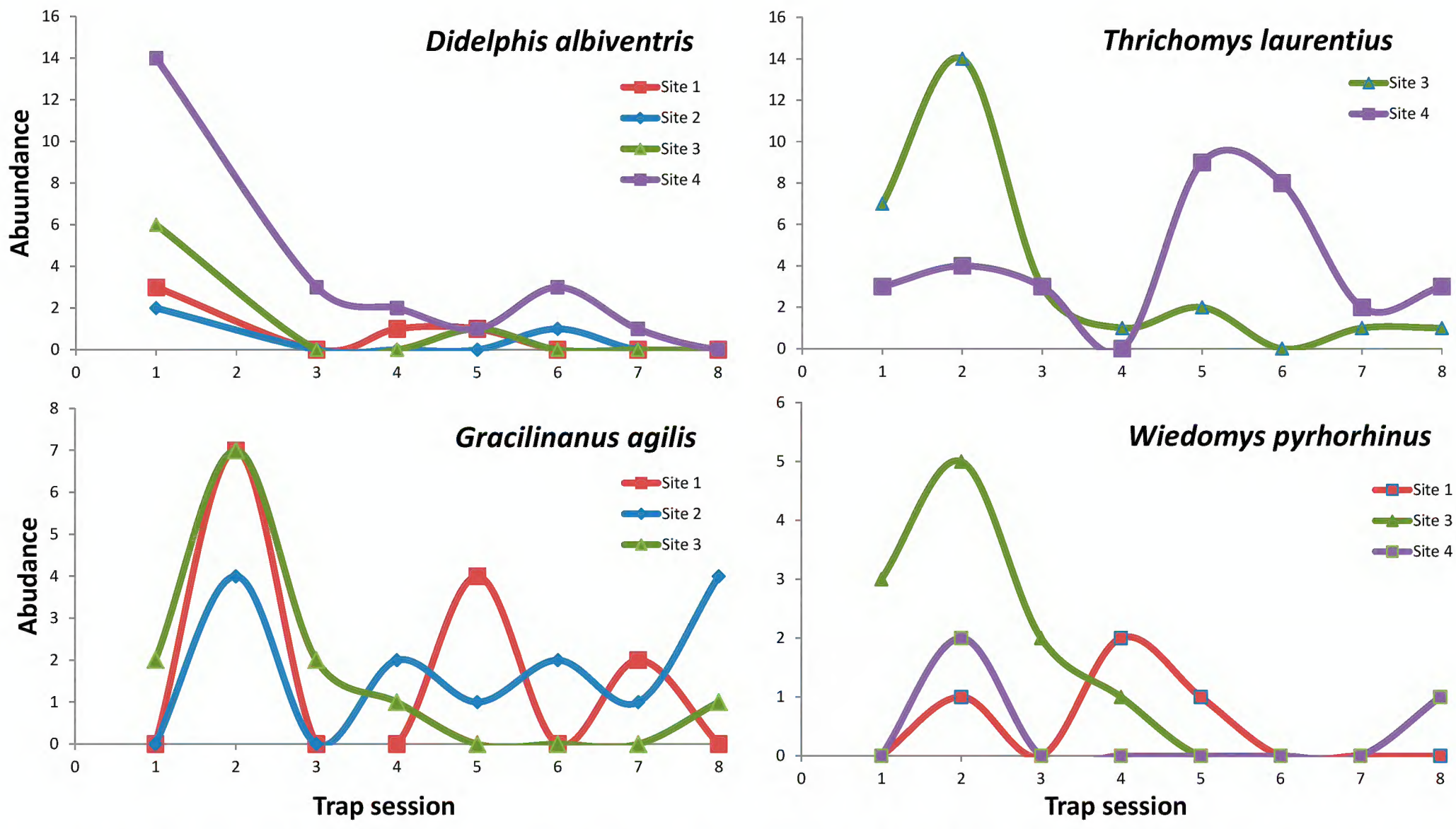


**Figure 5.** Abundance (number of capture individuals) fluctuation among sampling sessions for the more abundant species of non-volant small mammals in the study sites in northeastern Brazil. Abundances of *Didelphis albiventris* were correlated with precipitation in sites 3 and 4; and abundances of *Gracilinanus agilis* were correlated with precipitation with lag and precipitation in site 2 (see Table 3). August is the driest month, and March is the month with the highest rainfall. Sampling sessions: 1= April 2010; 2= October 2010; 3= March 2011; 4= October 2011; 5= April 2012; 6= December 2012; 7= April 2013; 8= October 2013.

**Figure 6.** Medium-sized and large mammals species recorded in Caatinga areas in the municipalities of São João do Piauí, state of Piauí, and Ouricuri, state of Pernambuco, northeastern Brazil: **A)** captive *Cerdocyon thous*; **B)** *Conepatus semistriatus*; **C)** captive *Leopardus tigrinus*; **D)** *Procyon cancrivorus*; **E)** *Euphractus sexcinctus*; **F)** *Dasypus septemcinctus*; **G)** *Tamandua tetradactyla*; **H)** *Callithrix jacchus*; **I)** *Kerodon rupestris*; **J)** footprints of *Sylvilagus brasiliensis*; **K)** footprints of *Leopardus pardalis*. Photos by Ana C. Delciellos, except photo E by Mara Silva.

**Figure 7.** Mammal species recorded by camera traps in Caatinga areas in the municipalities of São João do Piauí, state of Piauí, and Ouricuri, state of Pernambuco, northeastern Brazil: **A)** *Conepatus semistriatus*; **B)** *Procyon cancrivorus*; **C)** *Cerdocyon thous*; **D)** *Leopardus* sp.; **E)** *Cerdocyon thous*; **F)** *Mazama* sp.; **G)** *Dasyprocta prymnolopha*; **H)** *Mazama* sp.

of Colônia do Piauí, state of Piauí, 07°29′40.6″ S, 040°27′04.2″ W), and one visualization in the same highway (07°41′08.5″ S, 042°01′23.0″ W), the last two records out of the study area.

Among felines, individuals of *Leopardus tigrinus* were observed in all sites, except site 3, and individuals of *Leopardus* sp. were recorded by camera traps in all sites, except site 2 (Table 1). A domesticated individual of *L. tigrinus* was observed in captivity in site 4, having been captured as young in the region as reported by a local (Figure 6). The carcass of a *Puma yagouaroundi*, killed in retaliation for livestock predation, was obtained with a local (Table 1). *Procyon cancrivorus* was frequently recorded by their characteristic footprints on the margins of weirs in all sites (Table 1). A total of 25 independent records for this species were obtained in active search for direct and indirect traces and in night censuses. *Procyon cancrivorus* was also recorded by camera-trap (site 2), and one road-killed individual was found in site 1 (Table 1; Figures 6 and 7).

Order Cingulata

In site 2, the carcass of a *Euphractus sexcinctus*, hunted to be used as food, was obtained with a local (Table 1; Figure 6). Three individuals of *Dasypus septemcinctus* were captured in site 1, one in a pitfall trap and two, one female and one male, in the same Tomahawk in April 2013 (wet season) (Figure 6).

Order Didelphimorphia

*Didelphis albiventris* was more abundant in site 4, and an abundance peak was detected in April 2010 (wet season) (Figures 3 and 5). Abundances of *D. albiventris* were correlated with precipitation in sites 3 and 4, with higher abundances in trap sessions with greater precipitation (Figure 5; Table 3). Young and subadult individuals correspond to about 53% of the total individuals captured, and 57% of those individuals were captured in April (wet season). Females with 3–6 young in the pouch were captured in March, April (wet season), and October (dry season) on site 4. Two of these females were young with upper dentition dP3M2, indicating early reproductive onset. For *G. agilis*, two captures occurred in pitfall traps and 97% in Sherman traps. It was the more abundant species in site 2 (Figure 3), and a peak of abundance was observed in October 2010 (dry season) in all sites (Figure 5). Abundances of *G. agilis* were correlated with precipitation with lag and precipitation in site 2, with a higher abundance in the hottest and drier trap sessions (Figure 5; Table 3). All captured individuals were subadults or adults, except for one young (dP3M2/dP3M(3)) captured in July 2010 (dry season) on site 4. Four individuals of *Monodelphis domestica* were captured (Table 1; Figure 2). One adult female was captured in a pitfall trap in April 2010 (wet season) in site 1, with eight young attached to the teats. Other three individuals were captured in Tomahawks in June 2010 (dry season).

**Table 3.** Spearman correlations between species richness, capture success and abundance of *Didelphis albiventris*, *Gracilinanus agilis*, *Thrichomys laurentius* and *Wiedomys pyrrhorhinos* with monthly precipitation (Prec), monthly precipitation with a time-lag of three months (Prec lag), mean compensated temperature (Temp) and mean compensated temperature with a time-lag of three months (Temp lag) in São João do Piauí (sites 1 and 2) and Ouricuri (sites 3 and 4), northeastern Brazil. Bold correlations are significant at $p < 0.05$.

| | | **Species richness** | **Capture success** | ***D. albiventris*** | ***G. agilis*** | ***T. laurentius*** | ***W. pyrrhorhinos*** |
|---|---|---|---|---|---|---|---|
| Site 1 | Prec | –0.1926 | –0.3582 | 0.3986 | –0.3068 | | –0.5286 |
| | | $p = 0.648$ | $p = 0.384$ | $p = 0.328$ | $p = 0.460$ | | $p = 0.178$ |
| | Prec lag | 0.0170 | 0.0255 | 0.4698 | –0.1706 | | –0.4872 |
| | | $p = 0.968$ | $p = 0.952$ | $p = 0.240$ | $p = 0.686$ | | $p = 0.221$ |
| | Temp | 0.0990 | 0.2029 | –0.4723 | 0.3041 | | 0.4823 |
| | | $p = 0.816$ | $p = 0.630$ | $p = 0.237$ | $p = 0.464$ | | $p = 0.226$ |
| | Temp lag | –0.5577 | –0.3122 | –0.6530 | 0.0422 | | –0.3095 |
| | | $p = 0.151$ | $p = 0.451$ | $p = 0.079$ | $p = 0.921$ | | $p = 0.456$ |
| Site 2 | Prec | 0.0978 | –0.2270 | 0.0504 | –0.6535 | | |
| | | $p = 0.818$ | $p = 0.589$ | $p = 0.906$ | $p = 0.079$ | | |
| | Prec lag | 0.0829 | –0.2625 | 0.4459 | –0.7232 | | |
| | | $p = 0.845$ | $p = 0.530$ | $p = 0.268$ | **$p = 0.043$** | | |
| | Temp | –0.0745 | 0.3696 | –0.2139 | 0.8326 | | |
| | | $p = 0.861$ | $p = 0.367$ | $p = 0.611$ | **$p = 0.010$** | | |
| | Temp lag | –0.6927 | –0.4688 | –0.2115 | 0.1036 | | |
| | | $p = 0.057$ | $p = 0.241$ | $p = 0.615$ | $p = 0.807$ | | |
| Site 3 | Prec | 0.5860 | 0.4539 | 0.8332 | 0.0999 | 0.2514 | 0.3662 |
| | | $p = 0.127$ | $p = 0.259$ | **$p = 0.010$** | $p = 0.814$ | $p = 0.548$ | $p = 0.372$ |
| | Prec lag | 0.1641 | 0.1405 | 0.6164 | –0.1803 | 0.0133 | 0.0386 |
| | | $p = 0.698$ | $p = 0.740$ | $p = 0.104$ | $p = 0.669$ | $p = 0.975$ | $p = 0.928$ |
| | Temp | –0.5757 | –0.3326 | –0.5687 | –0.0802 | –0.1849 | –0.2990 |
| | | $p = 0.135$ | $p = 0.421$ | $p = 0.141$ | $p = 0.850$ | $p = 0.661$ | $p = 0.472$ |
| | Temp lag | 0.0025 | –0.1705 | –0.2140 | –0.1513 | –0.1993 | –0.1168 |
| | | $p = 0.995$ | $p = 0.686$ | $p = 0.611$ | $p = 0.721$ | $p = 0.636$ | $p = 0.783$ |
| Site 4 | Prec | 0.6802 | 0.4861 | 0.8016 | | –0.4164 | –0.3250 |
| | | $p = 0.063$ | $p = 0.222$ | **$p = 0.017$** | | $p = 0.305$ | $p = 0.432$ |
| | Prec lag | 0.3303 | 0.2848 | 0.6004 | | –0.2606 | –0.4420 |
| | | $p = 0.424$ | $p = 0.494$ | $p = 0.115$ | | $p = 0.533$ | $p = 0.273$ |
| | Temp | –0.5133 | –0.2683 | –0.5835 | | 0.4335 | 0.3224 |
| | | $p = 0.193$ | $p = 0.521$ | $p = 0.129$ | | $p = 0.283$ | $p = 0.436$ |
| | Temp lag | 0.0101 | –0.2220 | –0.1101 | | 0.0790 | –0.3739 |
| | | $p = 0.981$ | $p = 0.597$ | $p = 0.795$ | | $p = 0.852$ | $p = 0.362$ |

Order Pilosa

*Tamandua tetradactyla* was recorded once in site 2 (Table 1). Additionally, two road-killed individuals were found on highway PI-143 (Municipality of Colônia do Piauí, State of Piauí, 07°36′29.3″ S, 042°03′39.6″ W and 07°32′54.0″ S, 042°04′44.0″ W) outside of the study area (Figure 6).

Order Primates

*Callithrix jacchus* was recorded in all sites, including groups of up to five individuals and groups crossing a paved highway in site 1 (Figure 6).

Order Rodentia

Only two individuals of *C. expulsus* and *O. stramineus* were captured with pitfalls traps in Ouricuri (site 4; Table 1; Figure 2), in the same sampling session (April 2010 and June 2010, respectively). Also, one *N. lasiurus* was captured in site 3 and two in site 4 in Ouricuri (Table 1), in the same sampling session in June 2010 (dry season). *Dasyprocta prymnolopha* was recorded only in site 1 by camera traps and by one specimen hunted by a local to be used as food (Figure 7). Seven individuals of *G. spixii* were captured considering the four sites (Table 1; Figures 2 and 3). One adult individual marked in March 2011 was recaptured after one year, in April 2012, in site 4. Several individuals of *Kerodon rupestris* active during the twilight were recorded in all sampling sessions in site 3 (Table 1; Figure 6).

*Thrichomys laurentius* was especially abundant in sites 3 and 4, with abundance peaks in October 2010 (dry season) and April 2012 (wet season) (Figures 3 and 5). This species was not captured on site 2 in Piauí (Table 1). In site 1, three individuals, one adult and two young, were observed in a rock crevice near the edge of a weir near this site in April 2012 (wet season; Table 1; Figure 2). In site 3.3% of individuals captured in Tomahawk were predated within the trap by a non-identified medium-sized or large mammal. Among them, in March 2011 (wet season), a female with four young in the uterus was recorded. Only 5% of the captures occurred in Sherman placed above ground. *Wiedomys pyrrhorhinos* was the fourth most abundant species (Figures 2 and 3), and abundance peaks were observed in October 2010 and 2011 (dry season) (Figure 5). In this species females comprised only 10% of the captured individuals. Abundance of both species was not correlated with precipitation and temperature (Table 3).

## DISCUSSION

The species richness recorded corresponds to ca. 30% of the non-volant mammal species having potential occurrence in the Caatinga according to Carmignotto et al. (2012). Two endemic rodents, *Kerodon rupestris* and *Wiedomys pyrrhorhinos* (Oliveira et al. 2003a), were recorded. Only three species (*Leopardus tigrinus*, *Leopardus pardalis*, and *Puma yagouaroundi*) classified as threatened with extinction according to the Brazil's national list (MMA 2014) were recorded. The main threats to these species are habitat loss and fragmentation, as well as sport hunting, fur trade, retaliation against livestock predation, and domestication, the latter in the case of *L. tigrinus* (Machado et al. 2008; Almeida et al. 2013). During this research, I observed some of these impacts in the studied areas, including one *P. yagouaroundi* killed in retaliation, and one *L. tigrinus* that was domesticated.

The low capture success and species richness compared to that frequently observed in other biomes were the common pattern found for non-volant small mammals communities in other areas within the Caatinga (e.g., Freitas et al. 2005; Bezerra et al. 2014). Freitas et al. (2005) and Bezerra et al. (2014) recorded six and eight species of non-volant small mammals in a global capture success of 0.56% (total sampling effort = 8,952 trap-nights) and 1.54-0.27% (total sampling effort = 5,369 trap-nights and 2,880 bucket-nights), respectively. Here, I recorded nine species and a mean capture success of 1.5%, the same pattern observed in the previous studies for non-volant small mammals. Capture success and relative richness were not correlated with monthly precipitation and temperature in all sites. However, in its deconstructive approach, Oliveira and Diniz-Filho (2010) found that the main driver of mammal's species richness in the Caatinga biome is the temperature, not the rainfall.

*Thrichomys laurentius*, *D. albiventris*, and *G. agilis* were the most abundant species in non-volant communities, as detected in previous studies in other Caatinga localities (e.g., Freitas et al. 2005). *Thrichomys laurentius* is a common rodent species, with herbivorous and semiterrestrial habits (Reis et al. 2011). It reproduces twice or three times a year, nesting on tree holes or galleries in soil and rock crevices (Reis et al. 2011). Peaks of abundance were detected in October 2010 (dry season) and April 2012 (wet season), but the time interval between sampling sessions probably prevents the detection of all the reproductive events. *Didelphis albiventris* is a common species in a variety of natural and disturbed areas (Mares et al. 1986). It is an omnivore and an important seed disperser (Cáceres 2002). Abundance peaks were detected in April 2010 (wet season), including the record of early reproductive onset that would be related to the production of more than one litter in the favorable season of the year and had already been observed for *D. albiventris* in another biome (Astúa and Geise 2006). *Gracilinanus agilis* is a small arboreal marsupial, often associated with forested habitats, and with an insectivorous/omnivorous diet (Bocchiglieri et al. 2010; Reis et al. 2011). Apparently there are no

previous studies about its population dynamics in other areas of Caatinga. *Wiedomys pyrrhorhinos* was the fourth species more abundant in communities, and abundance peaks were observed in October 2010 and 2011 (dry season). Although little is known about its biology and ecology, it is considered a rare rodent that shows notable population fluctuations in semi-arid regions (Sobral and Oliveira 2014). Only 10% of captured individuals were females, which is in contrast to a previous study that found sex ratios skewed toward females (Sobral and Oliveira 2014).

For *Calomys expulsus*, *Necromys lasiurus* and *Oligoryzomys stramineus,* 2–3 individuals each were captured in Ouricuri. I speculate that rarity in these species could be explained by the low population density in the community, or large interannual fluctuations in populations, both reducing the likelihood of captures of new individuals. Previous studies on population dynamics of these species in the Caatinga are practically nonexistent. Only *Necromys lasiurus* is relatively well-studied in other biomes and is often considered an abundant species, although its average population density estimates varies greatly in different localities and habitat types (Becker et al. 2007: 19 ind/ha in Emas National Park; Rocha 2011: 2 ind/ha at the Águas Emendadas Ecological Station). However, population fluctuations are often observed, with cycles of two or three years (Feliciano et al. 2002; Magnusson et al. 2010; Rocha 2011).

Among medium-sized and large mammals, *Cerdocyon thous* had the highest number of records in all sites and sampling sessions. This species has a wide geographical distribution, occurring in almost all biomes of Brazil and in neighboring countries (Beisiegel et al. 2013). It is a common species of nocturnal and crepuscular habit, with a wide diet that varies seasonally, and is omnivorous, a generalist and opportunistic (Beisiegel et al. 2013). This species has one of the highest road-kill rates on Brazilian highways (Cherem et al. 2007; Hengemuhle and Cademartori 2008; Turci and Bernarde 2009; Reis et al. 2011).

For Caatinga mammals, studies on population dynamics and community structure are practically nonexistent. For the studied areas, there is only one previous study performed in Ouricuri that recorded six species of mammals (Miranda and Miranda 1982). In this context, the present study contributes to the natural history and ecology of Caatinga mammals in sites close to priority areas for conservation.

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## APPENDIX

**Table A1.** Body mass (W; g), head-body length (HB; mm) and tail length (T; mm) for the specimens captured with live-traps in the municipalities of São João do Piauí, state of Piauí (sites 1 and 2), and Ouricuri, state of Pernambuco (sites 3 and 4), northeastern Brazil. For Didelphidae only adult specimens were considered. N is the number of different individuals measured.

| | | | Females | | | Males | | |
|---|---|---|---|---|---|---|---|---|
| **Species** | | **Site** | **Mean** | **Standard deviation** | **N** | **Mean** | **Standard deviation** | **N** |
| *Didelphis albiventris* | W | 3 | 453.3 | 50.6 | 3 | - | - | - |
| | HB | 3 | 296.7 | 20.2 | 3 | - | - | - |
| | T | 3 | 301.3 | 5.5 | 3 | - | - | - |
| *Didelphis albiventris* | W | 4 | 476.3 | 125.2 | 8 | 672.9 | 203.5 | 7 |
| | HB | 4 | 286.6 | 26.3 | 8 | 305.5 | 31.5 | 8 |
| | T | 4 | 291.3 | 24.6 | 8 | 306.1 | 21.9 | 8 |
| *Calomys expulsus* | W | 4 | 26.0 | - | 1 | 24.0 | - | 1 |
| | HB | 4 | 105.0 | - | 1 | 102.0 | - | 1 |
| | T | 4 | - | - | - | 66.0 | - | 1 |
| *Dasypus septemcinctus* | W | 1 | 890.0 | - | 1 | 825.0 | 7.1 | 2 |
| | HB | 1 | 253.0 | - | 1 | 256.5 | 9.2 | 2 |
| | T | 1 | 174.0 | - | 1 | 181.5 | 41.7 | 2 |
| *Galea spixii* | W | 1 | 266.0 | - | 1 | - | - | - |
| | HB | 1 | 223.0 | - | 1 | - | - | - |
| *Galea spixii* | W | 2 | 363.3 | 25.2 | 3 | 229.0 | - | 1 |
| | HB | 2 | 256.7 | 5.0 | 3 | 217.0 | - | 1 |
| *Gracilinanus agilis* | W | 1 | 16.0 | 6.9 | 3 | 24.8 | 9.8 | 8 |
| | HB | 1 | 94.0 | 7.2 | 3 | 104.3 | 15.9 | 8 |
| | T | 1 | 122.7 | 14.4 | 3 | 134.3 | 9.7 | 8 |
| *Gracilinanus agilis* | W | 2 | 18.9 | 6.7 | 8 | 23.8 | 5.2 | 9 |
| | HB | 2 | 92.6 | 10.7 | 9 | 105.7 | 9.8 | 9 |
| | T | 2 | 125.0 | 8.3 | 9 | 137.4 | 9.2 | 9 |
| *Gracilinanus agilis* | W | 3 | 22.3 | 4.6 | 2 | 30.5 | 27.8 | 8 |
| | HB | 3 | 96.5 | 16.3 | 2 | 98.5 | 13.7 | 8 |
| | T | 3 | 128.5 | 16.3 | 2 | 134.4 | 18.6 | 8 |
| *Gracilinanus agilis* | W | 4 | 20.9 | 7.7 | 8 | 23.8 | 7.0 | 10 |
| | HB | 4 | 105.9 | 39.1 | 8 | 100.2 | 7.0 | 10 |
| | T | 4 | 124.5 | 10.0 | 8 | 132.9 | 10.0 | 10 |
| *Kerodon rupestris* | W | 3 | - | - | - | 234.0 | - | 1 |
| | HB | 3 | - | - | - | 246.0 | - | 1 |
| *Monodelphis domestica* | W | 1 | 78.0 | - | 1 | 131.5 | 9.2 | 2 |
| | HB | 1 | 133.0 | - | 1 | 118.0 | 58.0 | 2 |
| | T | 1 | 90.0 | - | 1 | 109.5 | 0.8 | 2 |
| *Monodelphis domestica* | W | 2 | - | - | - | 30.0 | - | 1 |
| | HB | 2 | - | - | - | 127.0 | - | 1 |
| | T | 2 | - | - | - | 79.0 | - | 1 |
| *Necromys lasiurus* | W | 3 | - | - | - | 36.0 | - | 1 |
| | HB | 3 | - | - | - | 94.0 | - | 1 |
| | T | 3 | - | - | - | 86.0 | - | 1 |
| *Necromys lasiurus* | W | 4 | - | - | - | 36.5 | 16.3 | 2 |
| | HB | 4 | - | - | - | 99.5 | 0.7 | 2 |
| | T | 4 | - | - | - | 84.0 | 8.5 | 2 |
| *Oligoryzomys stramineus* | W | 4 | - | - | - | 16.0 | 0.0 | 2 |
| | HB | 4 | - | - | - | 84.5 | 9.2 | 2 |
| | T | 4 | - | - | - | 103.0 | 19.8 | 2 |

*Continued*

**Table A1.** *Continued.*

| Species | | Site | Females | | | Males | | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean | Standard deviation | N | Mean | Standard deviation | N |
| *Thrichomys laurentius* | W | 1 | - | - | - | 166.5 | 65.8 | 2 |
| | HB | 1 | - | - | - | 168.0 | 12.7 | 2 |
| | T | 1 | - | - | - | 194.0 | 17.0 | 2 |
| *Thrichomys laurentius* | W | 3 | 188.2 | 40.0 | 12 | 196.8 | 36.9 | 12 |
| | HB | 3 | 188.3 | 36.8 | 10 | 213.7 | 20.1 | 12 |
| | T | 3 | 168.8 | 47.7 | 9 | 187.5 | 23.5 | 12 |
| *Thrichomys laurentius* | W | 4 | 182.5 | 43.5 | 15 | 227.8 | 61.1 | 13 |
| | HB | 4 | 190.9 | 15.6 | 15 | 207.8 | 22.9 | 12 |
| | T | 4 | 172.3 | 29.8 | 12 | 190.5 | 40.2 | 12 |
| *Wiedomys pyrrhorhinos* | W | 1 | 32.7 | 10.7 | 3 | 40.0 | 2.8 | 2 |
| | HB | 1 | 92.3 | 10.2 | 3 | 103.5 | 7.8 | 2 |
| | T | 1 | 169.0 | 30.5 | 3 | 165.5 | 0.7 | 2 |
| *Wiedomys pyrrhorhinos* | W | 2 | - | - | - | 29.3 | 10.0 | 3 |
| | HB | 2 | - | - | - | 73.3 | 46.2 | 3 |
| | T | 2 | - | - | - | 140.3 | 80.5 | 3 |
| *Wiedomys pyrrhorhinos* | W | 4 | - | - | - | 41.3 | 9.3 | 6 |
| | HB | 4 | - | - | - | 101.7 | 11.5 | 6 |
| | T | 4 | - | - | - | 177.7 | 14.0 | 6 |

**Table A2.** Voucher specimens collected in the municipalities of São João do Piauí, state of Piauí, and Ouricuri, state of Pernambuco, northeastern Brazil, and deposited at the Museu Nacional, Universidade Federal do Rio de Janeiro.

| Species | Voucher specimens |
|---|---|
| *Calomys expulsus* | MN75039, MN75040 |
| *Cerdocyon thous* | MN75036, MN75049, MN75981 |
| *Dasyprocta prymnolopha* | MN75050 |
| *Didelphis albiventris* | MN75041, MN75042 |
| *Euphractus sexcinctus* | MN75048 |
| *Galea spixii* | MN75045 |
| *Gracilinanus agilis* | MN75982, MN75986 |
| *Kerodon rupestris* | MN75046 |
| *Oligoryzomys stramineus* | MN75983, MN75984 |
| *Puma yagouaroundi* | MN75985 |
| *Tamandua tetradactyla* | MN75037, MN75044 |
| *Thrichomys laurentius* | MN75038, MN75051, MN75052, MN75318, MN75987, MN75988, MN75989, MN75990, MN75991, MN75992, MN75993, MN75994, MN77801, MN77802, MN77803 |